THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE PHYSICS OF CRYSTALLINE SURFACES

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Third Quarterly Status Report
For the Period 1 August-31 October 1966

Prepared for the
National Aeronautics and Space Administration
Washington, D. C.

Fund Transfer R-05-030-001

U. S. Naval Ordnance Test Station
China Lake, California 93555

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I. The relation between structure of epitaxial films and surface and interfacial energies (A. K. Green and E. Bauer).

The experiments on the epitaxy of f.c.c. metals on alkali halides in ultrahigh vacuum described in the two previous reports had demonstrated the strong influence of the surface condition on the nucleation rate and the coalescence processes, but had shown little influence on the orientation of the nuclei. On the other hand, previous studies of the growth of alkali halides on alkali halides (A. K. Green and E. Bauer, J. Appl. Phys. 37, 917 (1966)) in ordinary vacuum had indicated that the surface condition as determined by the residual gas environment influenced the orientation of the nuclei. In order to elucidate the influence of the surface condition on the nucleation process an effort was made within this report period to study the nucleation of NaCl on NaCl deposited simultaneously onto surfaces cleaved in ultrahigh vacuum and cleaved in air. The experiments were performed in the ultrahigh vacuum electron diffraction unit described previously (see 1st Quarterly Status Report). Adequate radiation shielding was not possible due to space limitations and outgassing proved to be a severe problem. As a consequence, the results obtained were not entirely reproducible. One of the more significant reproducible results was that the number of twin nuclei was always much larger on the ultrahigh vacuum cleaved surface than on the air cleaved surface. This is quite surprising because the formation of twinned crystals is usually assumed to be assisted by impurities and should therefore be more likely on the air cleaved side. Because of the experimental difficulties the experiments were terminated and will be resumed once improved equipment and techniques have been developed. In the meantime the equipment will be used for further study of specific problems in the growth of gold on alkali halides. Experiments have been started in another ultrahigh vacuum system with the goal of understanding the gas evolution from alkali halides upon heating which has been claimed to be a major factor in the epitaxy of f.c.c. metals on alkali halides (M. Harsdorff, Solid State Commun. 1, 218 (1963); 2, 133 (1964); Z. Naturforsch. 20a, 489 (1965); Fortschr. Miner. 42, 250 (1966)).

II. Quantitative studies of the elastic and inelastic interactions of slow electrons with W single crystal surfaces (J. O. Porteus).

Testing of an electrostatic ion pump is now in progress. Hopefully, replacement of the present oil diffusion pump with this unit will reduce the CO contamination to a tolerable level. Also, an automatic beam-tracking device is being constructed to obtain intensity vs. voltage data. Meanwhile, measurements of inelastic scattering from a W {110} surface are in progress. Angular distributions as well as the effect of changing the angle of incidence are being studied. These measurements must be regarded

as preliminary, however, in view of the presently inadequate vacuum conditions. Some improvements have been made in the mathematical method of differentiating inelastic scattering data in order to observe energy loss peaks.

III. Determination of nature and structure of surface layers with low energy electron diffraction (E. Bauer).

The work on the structure of SrO layers on the W {110} plane reported previously (see 2nd Quarterly Progress Report) had demonstrated clearly the need for a better understanding of the structure and stability of the high temperature interaction products between oxygen and the W {110} plane, of the structure and stability of the interaction products between carbon monoxide and the W {110} plane, and of the interpretation of low energy electron diffraction patterns from superimposed lattices with different orientation, dimensions and/or structure. The effort within the last report period was therefore concentrated on these three subjects. The study of oxygen on the W {110} plane which is still in progress revealed that the high temperature phases could be attributed to the four known bulk W-O phases forming thin epitaxial layers on the W {110} surface. It was also found that the W {110} plane oxidizes at room temperature once the oxygen coverage exceeds half a monolayer. The results are presently being written up. In the study of the interaction between CO and the W {110} plane it was found that the β phase of CO on W is not a chemisorbed layer but a thin layer of epitaxial $W(CO)_6$. In the study of the interpretation of superimposed lattices the following systems have been analyzed: Ag on Cu {111}, Ag on Cu {100}, O_2 on Rh {100}, C on W {110} and the highest temperature form of O_2 on W {110}. The results are presently being written up and will be included in the next report.

IV. Relation between structure and electron emission properties of work function reducing layers on W {110} planes (G. Turner and E. Bauer).

Work is continuing on the correlation between surface structure and electron emission properties of the SrO - W {110} system. Preparations are being made to extend the studies to include the BaO - W {110}, Sr - W {110}, and Ba - W {110} systems. As a part of this extended program, the development of intense, highly directional evaporation sources for the alkaline earths and their oxides has been undertaken. Modifications of the principle investigating instrument are being made to facilitate the study of these additional systems. A magnetic deflection system and appropriate electron optics are being added to the U.H.V. low energy reflection electron microscope in order to separate the incident beam from the imaging beam. This will remove the constraints that are imposed during straight beam operation and greatly increase the capabilities of the instrument.

V. Momentum exchange of atoms on well defined single crystal surfaces (W. Faith and E. Bauer).

The molecular beam attachment to the low energy electron diffraction system has gone through a series of in situ tests and modifications to

develop the optimum source and detection geometry and conditions, and to optimize the specimen manipulation setup (2 rotations, heating, exact alignment on axis). With argon at a pressure of 4.10^{-8} torr a peak to background ratio (for the incident beam) of 1.6 has been obtained, with a beam half-width of 8°. Better ratios and half-widths are expected with improvements in the experimental setup.

VII. Theory of low energy electron scattering (E. Bauer).

The physical phenomena which could reduce the importance of relativistic effects in the scattering of slow electrons by neutral atoms have been and are being investigated. These are the Pauli principle and the influence of the long range polarization on the scattering process. Results to date indicate that the two effects do not significantly alter the qualitative conclusions drawn earlier (H. N. Browne and E. Bauer, Phys. Rev. Letters 16, 495 (1966); 2nd Quarterly Status Report). More work, however, needs to be done to come to a final conclusion.